PIEZOELECTRIC ELEMENT WITH A MULTILAYER STRUCTURE OF PIEZOELECTRIC PLIES, AND A METHOD FOR PRODUCING IT

Prior Art

The invention concerns a piezoelectric element with a multilayer structure of piezoelectric plies and a method for producing it, e.g., for a piezoelectric actuator for actuating a mechanical component such as a valve or the like, according to the features—based on the general class—of the primary claim.

It is generally known that, by utilizing the "piezoelectric effect", a piezoelectric element can be constructed of a material having a suitable crystal structure. When an external electrical voltage is applied, a mechanical reaction of the piezoelectric element takes place that, depending on the crystal structure and the application regions of the electric voltage, represents a push or pull in a specifiable direction. The construction of this piezoelectric actuator can take place here in a plurality of layers (multilayer actuators), and the electrodes, via which the electrical voltage is applied, are always arranged between the layers. The respective internal electrodes are hereby always separated from the external electrodes by a space, so that a short circuit does not take place here. The expense to stack the individual piezoelectric plies is thereby very high, because up to many hundred individual film layers must be processed separately.

Advantages of the Invention

The piezoelectric element described initially having a multilayer structure of piezoelectric plies, with electrodes arranged between them and a lateral contacting of electrodes in alternate directions can advantageously be a component of a piezoelectric actuator that can be used to actuate a mechanical component such as a valve or the like. According to the invention, the individual piezoelectric plies are composed of a continuous film made of piezoceramic that

can be folded during manufacture, that are provided entirely or partially with electrically conductive electrodes on their surface.

In a preferred embodiment, the film for producing the electrodes is entirely or partially metallized, and the piezoelectric plies are formed by means of folding at notches applied at specified intervals transverse to the direction of folding, and the internal electrodes are formed by the metallized layers between the piezoelectric plies lying on the inside of the notches after the folding, and the metallized layers on the outside of the notches are interrupted by the notches.

The metallized layers can be applied, for example, by means of printing or sputtering. The internal electrodes are thereby contacted with the external electrodes on the insides of the notches projecting outward after the folding. The notch angle α can thereby be adapted individually to the thickness of the film or other circumstances.

In advantageous fashion, only every other surface between the notches can be metallized on at least one side of the film in each case without impairing the formation of internal electrodes.

External electrodes can be applied on the outside in each case in the notch region of the folded film in simple fashion to form the contacting at the metallized layer or the internal electrode in alternate directions, and the external electrodes can be composed of an electrically conductive screen or net, or of a wave electrode.

In order to insulate the entire piezoelectric element against the outside, the multilayer structure of the piezoelectric plies is provided with an electrically insulating ceramic plate on each end of the folded plies.

In an advantageous method for producing a piezoelectric element of the type described previously, the following production steps are carried out:

- The piezoelectric film is cut to the width of the piezoelectric element and provided with notches at specified intervals, always in alternate directions.

- The piezoelectric film is now entirely or partially metallized on both sides.

- The piezoelectric film is then folded at the notches, always around the inside of the notch.

- The external electrodes are e.g., soldered to the internal electrodes in the bending region in the inside of the notch projecting outward after the folding.

- One electrically insulating head and foot plate each are applied to the external piezoelectric plies.

These and further features of preferred further developments of the invention also arise from the description and the diagrams, in addition to the claims, and each of the individual features can be realized on its own or in plurality in the form of sub-combinations in the exemplary embodiment of the invention and in other fields, and can represent advantageous and patentable embodiments in themselves, for which protection is claimed here.

Sub A5 Diagram

An exemplary embodiment of the piezoelectric element according to the invention for forming a piezoelectric actuator is explained using the diagram.

Figure 1 shows a sectional view through a multilayer structure of the piezoelectric element composed of a piezoelectric film, produced by folding at the notches;

Figure 2 shows a detailed view of a notched film with continuous metallizing, and

Figure 3 shows a detailed view of a notched film with partial metallizing.

Description of the Exemplary Embodiment

A piezoelement 1 for forming a piezoelectric actuator is shown in Figure 1, that is constructed of a piezoelectric film 2 of a ceramic material having a suitable crystal structure, so that, by utilizing the "piezoelectric effect", a mechanical reaction of the piezoelectric actuator takes place in the direction of the arrow 3 when an external electrical voltage is applied.

It is obvious in Figure 1 that piezoelectric plies 4 are formed by means of a folding of the piezoelectric film 2 that is shown in the state before its folding in Figure 2. The piezoelectric film 2 was cut before folding to the width of the piezoelectric element 1 and metallized on both sides so that electrodes form that, after folding, act as internal electrodes 6 and 7, each in an alternate direction.

It is shown in Figure 2 that the piezoelectric film 2 has been provided with notches 5 (i.e., 5.1, 5.2 in the sectional view shown) before folding, which are thereby created in the film 2 in alternate directions and form an approximate angle α. The folding takes place here, e.g., in the notch 5.1 around the arrow 8, so that one of the internal electrodes (e.g., the internal electrode 6) forms on the left side after the folding-on top of each other. The other internal electrodes (one of the internal electrodes 7 here) form on the right side, also on both sides of the open side of the notch 5.1 in each case.

After laminating and sintering, the stack of piezoelectric plies 4 folded in this fashion is provided with external electrodes 9 and 10, each of which is composed of a metallized wave electrode in the exemplary embodiment shown. The external electrodes 9 and 10 are connected with the metallized layer on the piezoelectric plies 4 in electrically conductive fashion in the respective projecting folding region of the previous notches 5, so that an electrical voltage can be applied to the internal electrodes 6 and 7 to create the piezoelectric effect.

Additionally, one electrically insulating head plate 11 and a foot plate 12 each are applied to the external piezoelectric plies 4, by means of which the entire piezoelectric element 1 can be insulated against the outside.

According to Figure 3, which shows a piezoelectric film 20 in the state before its folding, only partial regions of the piezoelectric film 20 are provided with electrodes 21 and 22, in contrast to the piezoelectric film 2 according to Figure 2. These electrodes 21 and 22 are applied to one of the opposing sides of the piezoelectric film 20 in alternate directions in each case, so that piezoelectric plies 4 also form as described using Figure 1, but the resultant internal electrodes 21 and 22 here have a smaller thickness, because they are formed by means of a one-sided coating only.